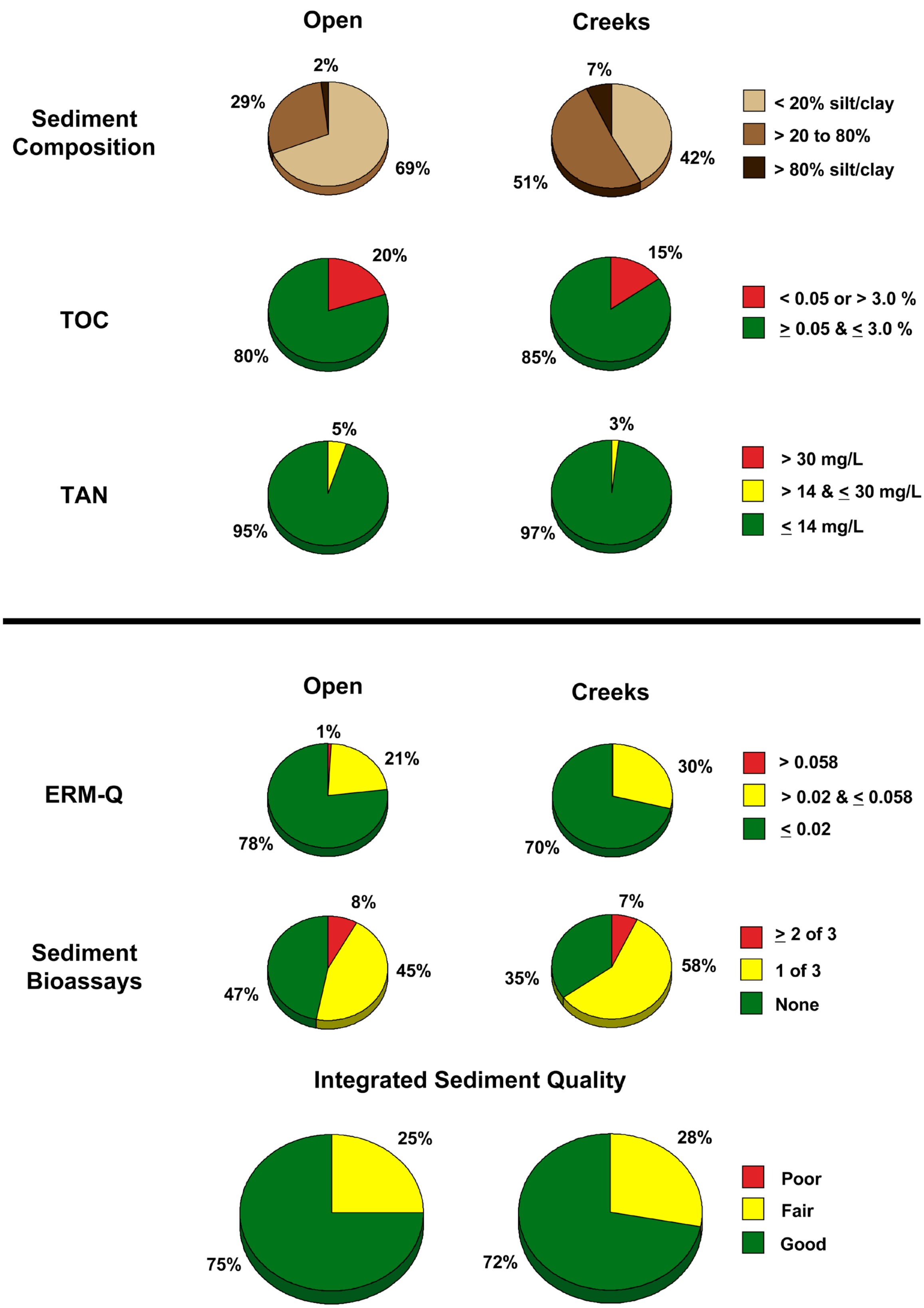
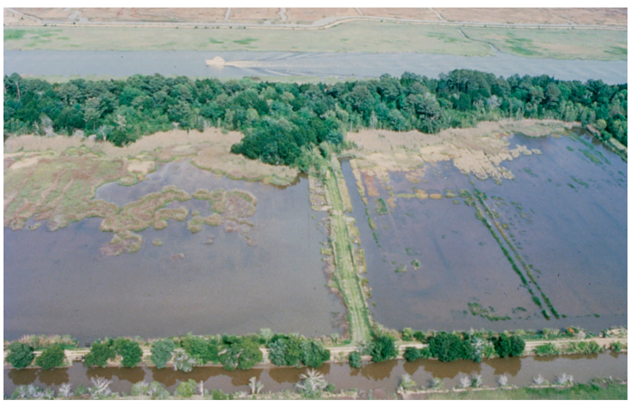


Figure 3.3.1. Comparison of the percent of the state's coastal habitat represented by various sediment quality conditions and integrated sediment quality scores.

in tidal creek habitats, a difference that was not significant. The TAN of open water habitats varied from 0.15 to 30.5 mg/L and that of tidal creeks varied from 0.1 to 25.3 mg/L. On average, less than half of one percent of South Carolina's open water or tidal creek habitat possessed ammonia concentrations characteristics of high stress habitats (Figure 3.3.1). A single station in open water had a TAN concentration of 30.5 mg/L but all remaining open water stations had TAN concentrations of less than 16 mg/L. The unusually high TAN concentration was found at station RO046076 near the confluence of Six Mile Creek and the Santee River. The area surrounding this station consists of extensive impoundments for waterfowl that may act as sources of nitrogen when water is released into the estuary during the late spring and summer.



The Santee River delta is highly impounded to attract waterfowl.

Contaminants

Contaminants enter coastal water bodies through direct release by users, runoff from terrestrial systems, and deposition from suspended material in the atmosphere. Common environmental contaminants include polycyclic aromatic hydrocarbons (PAHs; including compounds such as automobile oil), heavy metals (including mercury, chromium, etc), polychlorinated biphenyls (PCB's; including components of many flame retardants and electrical insulators manufactured before 1979) and pesticides (including DDT, etc.). Although SCECAP determined the levels of 160 contaminants in South Carolina's coastal waters, the consequences of many of these compounds to ecosystem function and human health remain uncertain.

Long and Morgan (1990) and Long *et al.* (1995, 1997) reviewed published toxicological studies involving 24 contaminants (all measured by SCECAP) and developed two metrics: Effects Range-Low (ER-L; concentration of a contaminant that resulted in adverse bioeffects in 10% of published studies) and Effects Range-Median (ER-M; concentration of a contaminant that resulted in adverse bioeffects in 50% of published studies). During the 2003-2004 monitoring period, 33 stations (including 12 open water and 21 tidal creek stations) had at least one contaminant that exceeded its published ER-L, and no station had a contaminant that exceeded its published ER-M. Four PAH's, the pesticide DDT, and 5 metals exceeded published ER-L (Table 3.3.1). The most widespread contaminant that exceeded its ER-L was arsenic. Arsenic accumulates in estuarine sediments as a result of the weathering of terrestrial rock, thus its presence in South Carolina's coastal sediments (particularly in tidal creeks) is likely a result of natural upland erosion. Disturbance of these sediments, such as may occur through slumping, erosion or dredging, however, can re-suspend buried arsenic (Saulnier and Mucci, 2000) making it available for uptake by estuarine fauna and increasing chances of contact with the human population.

To assess the overall bioeffect of the 24 contaminants with published guidelines, an Effects Range Median Quotient (ERM-Q) was calculated for each station. ERM-Q is calculated by dividing the measured concentration of each of the 24 contaminants by its ER-M values and then averaging the 24 values. Hyland *et al.* (1999) demonstrated that ERM-Q provides a reliable index of benthic stress in southeastern estuaries, with ERM-Q values ≤ 0.020 representing a low risk, values > 0.020 and ≤ 0.058 representing a moderate risk, and values > 0.058 representing a high risk of observing degraded benthic communities. The median ERM-Q of open water sediments was 0.010 and that of tidal creeks was 0.014, a difference that was not significant. ERM-Q varied from 0.001 to 0.076 in open water habitats and from 0.003 to 0.056 in tidal creek habitats. ERM-Q values were in the moderate risk range in 30% of the state's tidal creek habitat and 21% of the state's open water habitat and in the high risk range in 1% of the state's open water habitat (Figure 3.3.1). One open

Table 3.3.1. Contaminants that exceeded published ER-L. Also shown is the number of stations in each habitat type where this occurred.

Contaminant Type	Name	Number of Stations
PAH	Acenaphthene	2; RO036042, RO046071
	Anthracene	3; RO036042, RO036153, RT042067
	Fluorene	1; RO032032
	2-methylnapthalene	2; RO036044, RT042194
Pesticide	DDT	2; RO036044, RT042194
Metal	Arsenic	25; 8 open water, 17 tidal creek
	Cadmium	1; RO046073
	Copper	1; RO042070
	Lead	1; RT042193
	Nickel	7; RT032174, RT032188, RT046062, RT042070, RO046064, RO046076, RO046078

water station had an ERM-Q value within the high risk range: RO036042 in the Cooper River northeast of the mouth of Goose Creek (ERM-Q = 0.077). The Cooper River is extensively developed for industrial purposes, and the SCECAP station assessed here was situated near a U.S. Naval ammunition depot. This station was characterized by unusually high metal, PAH, PCB, and pesticide levels.

Coastal ERM-Q values have increased significantly since the start of SCECAP in 1999, particularly in open water habitats ($P = 0.018$; Table 3.3.2). Similarly, the percent of tidal creek and open water habitat in South Carolina having ERM-Q values indicative of moderate to high risk of contamination has increased consistently from 21% to 30% in tidal creek habitats and from 12% to 22% in open water habitats (Figure 3.3.2). A significant increase in metal concentrations ($P < 0.0005$) and increasing PAH contamination contributed most heavily to the increasing ERM-Q.

The Cooper River at Charleston is a busy shipping port and a heavily developed industrial area.

Table 3.3.2. Average ERM-Q values in open water and tidal creek habitats between 1999 and 2004. Averages were used rather than medians because only ERM-Q in developing and potentially polluted watersheds (a relatively small percent of SC coastal watersheds) would be expected to change over time, a response that would not be reflected by medians.

Habitat	1999	2000	2001	2002	2003	2004
Tidal Creek	0.0126	0.0131	0.0132	0.0171	0.0145	0.0152
Open Water	0.0148	0.0145	0.0175	0.0154	0.0180	0.0163

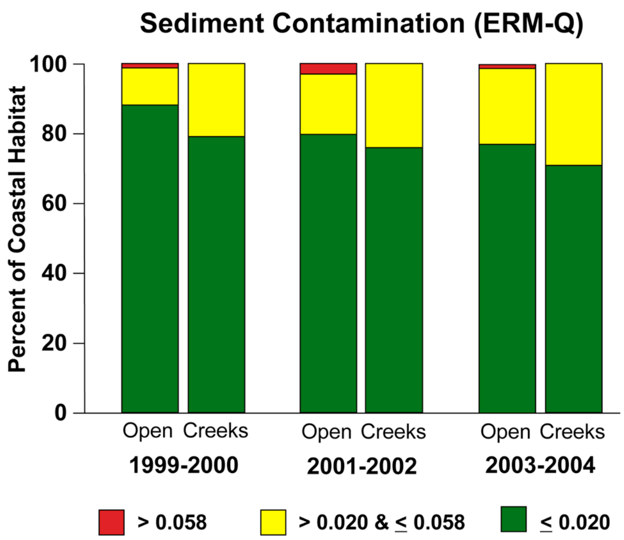


Figure 3.3.2. Change in ERM-Q in open water and tidal creek habitat since the start of SCECAP monitoring in 1999.

Toxicity Bioassays

Sediments may contain a wide range of contaminants, but the ability of those contaminants to negatively impact healthy biological communities depends on their availability to the resident fauna as well as interactive effects among the contaminants. Bioassays provide a means of determining the biological relevance of contaminant loads by examining the performance of living organisms in samples of native sediment (Ringwood and Keppler, 1998).

This SCECAP study applied three bioassays simultaneously—Microtox® bacterial growth, seed clam growth and amphipod survivorship—in order to provide a weight of evidence estimate of sediment toxicity to benthic fauna. Positive test results in at least two of the three assays indicates a high probability of toxic sediments, positive results in only one of the three assays indicates possible evidence of toxic sediments and no positive results indicates non-toxic sediments. Using these guidelines, 8% of the open water and 7% of the tidal creek habitat in South Carolina had a high probability of containing toxic sediments, and an additional 45% of open water and 58% of tidal creek habitat had evidence of possible toxicity (Figure 3.3.1).

Using the data available from all six years of SCECAP, we examined the ability of the bioassays to reflect ERM-Q scores. The number of assays showing positive results (excluding the amphipod assay) was significantly greater when ERM-Q scores were higher ($P < 0.0005$) indicating these assays provide a quantifiable estimation of sediment toxicity. While this describes a general tendency of the bioassays to detect toxicity at stations with higher contaminant loads, these bioassays did not entirely reflect contaminant levels. The amphipod assay produced only three positive results during the current study period, all at stations with good ERM-Q scores. This, combined with a general lack of amphipod toxicity in previous surveys, indicates that this assay does not perform well in this region. The Microtox® assay was very sensitive to stations with poor contaminant conditions (detected 100% of stations with high risk ERM-Q scores) but it displayed a tendency to generate many false positive results (detected toxic conditions at 41% of stations with good ERM-Q scores; Table 3.3.3). The clam assay was not as effective at detecting poor contaminant conditions (detected 43% of stations with high-risk ERM-Q

Table 3.3.3. Number of negative and positive Microtox® and seed clam bioassay results at stations with low, moderate and high risk ERM-Q scores. False positives are considered those assays with positive results at stations with a low-risk ERM-Q, and false negatives are considered those assays with negative results at stations with a high risk ERM-Q. By combining the Microtox and clam bioassays (combined columns), the ability to correctly detect low-risk (combined = 0), moderate-risk (combined = 1) and high-risk (combined = 2) improves.

	Microtox®		Clam		Combined		
ERM-Q	**-**	**+**	**-**	**+**	**0**	**1**	**2**
Low-risk	156	109	240	25	141	114	10
Moderate-risk	32	58	69	21	22	57	11
High-risk	0	7	4	3	0	4	3